Polymer Acoustic Guitars:
Designing In Credibility and Designing Out Prejudice

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Abstract
History tells us that the union of plastics and musical instruments is one fraught with both technical difficulties and human prejudice in the form of value judgements. For some seasoned guitarists, the idea of creating a guitar made not from wood but from plastics is at worst sacrilege and at best a promise of a very poor product experience. Nonetheless, guitar manufacturers have for decades searched for credible and tonally comparable synthetic replacements for wood.

This paper communicates the challenges that were faced in designing, from scratch, a credible and pleasurable acoustic guitar made almost entirely from plastics. The work builds upon the practical element of a PhD project, which now forms the basis of the branded business and R&D venture *Cool Acoustics,* owned wholly by Loughborough University.

The paper contrasts the sensorial information conveyed by wood and plastics and places the findings in the context of acoustic guitar design. The Cool Acoustics guitar project is then presented and its execution discussed, particularly in relation to the development of the first finalised prototype instruments exhibited at the Frankfurt Musikmesse in 2002. Tactical materials selection and finishing, along with effective form creation and branding, were used to redress the recurring inclination of industry and public alike to dismiss plastic musical instruments on emotional grounds. The findings of informal feedback sessions are used to gauge success against the stated aims of 'designing in credibility' and 'designing out prejudice'.

Keywords: designing, prejudice, credibility, projective emotions, plastic products, guitars

Introduction

Guitars consistently form the mainstay of musical instrument sales. Market conditions show annual growth in recent years of around 20% in the USA and UK, and annual guitar sales amount to £1.5bn globally. Wood continues to be the primary material choice, especially so for *acoustic* guitars, and for good reasons. Acoustic guitars are an excellent example of an "archetypal" product type (Thistlewood, 1990), having improved in iterative steps through the work of generations of craftspeople since the 1500s.

> [Archetypal products] represent a phase of human design enterprise before authorship was celebrated. The contemporary designer's contribution to their re-presentation consists in attending to secondary features such as materials, colours and decorative treatments: *essential* forms have ceased or virtually ceased evolving, and are correspondingly non-negotiable (Thistlewood, 1990).

Occasional evolutionary spurts have occurred along the way, most notably Antonio de Torres' contribution to the development of the Spanish classical guitar and C F Martin's contribution to the steel-strung acoustic guitar, but mainstream production is characteristically stagnated and remains firmly rooted in wood technology. The opportunity to realise product advantages and differentiation through a shift in materials technology is therefore wide open. But surprisingly few 'big brand' manufacturers offer non-wood acoustic guitars for sale. On the whole, it is the smaller manufacturers and experimentalist makers who use materials other than wood to create new and interesting instruments. One suspects that this state of affairs does not indicate inactivity by mass manufacturers: more likely that their 'alternative materials' instruments already exist, or are in preparation, and that the timing of their public debut is a highly sensitive commercial matter.

Materials and Guitar Innovation

Guitar manufacturers have for decades searched for credible and tonally comparable synthetic replacements for wood. This search continues today, and is undertaken with the promise of advantages to both manufacturers and guitarists (Owen, 2002; Roberts, 2001). For manufacturers, non-wood materials can bring competitive advantages regarding lower costs, consistency and availability of materials, simpler manufacture and assembly, and new ways to achieve product differentiation. Forecasts of diminishing wood supplies are also a major driver towards the adoption of alternative materials, with plastics predicted many years ago by Read (in Pearce, 1993:8) to have a role: "unless they [guitarists] change their ways radically, the trees [ebony and rosewood] will soon disappear and the woods, prized for their resonance, will be replaced by plastic."

For guitarists, there exists the tantalising proposition that synthetic materials and engineering mass production methods can result in learner instruments of a superior quality but with no additional financial outlay. This is a long-term goal for Cool Acoustics and one where success will depend largely on achieving positive emotional responses in the transition from wood to plastic.

Sensorial Information From Wood

Acoustic guitars are associated with the sensorial information conveyed by wood. Good acoustic guitars are prized for the way in which wood is skilfully worked into an object that is both desirable to behold and rewarding to play. Such instruments, aside from their technical prowess and quality of construction, typically exhibit magnificent wood grain and attention to detail (visual sensations), highly smoothed or polished surfaces (tactile sensations), exemplary tone (aural sensations) and the characteristically aged and refined smell of wood and varnish (olfactory sensations). And for the maker of guitars, being accustomed to the dusty air that is typical of a guitar workshop, saporous sensations of wood complete the experience.

With such a sensationally rich pedigree spanning many centuries, it is little wonder that acoustic guitars commonly elicit a sense of romanticism and an acute historical awareness amongst makers and players. The swathes of books charting guitar history and illustrating in great detail the evolution of various guitar models is a reflection of the interest and ownership that guitarists have in their instruments. This is perhaps more so than for any other musical instrument (e.g. Banks, 2001; Chapman, 1993; Gruhn & Carter, 1993; Bacon, 1991; Denyer, 1982). The romanticism towards wooden instruments, which sometimes extends to protectionism, originates from several convictions, of which the following are prominent.

- Wood is a naturally occurring material, relaying the power and beauty of Mother Earth and instilling a sense of time, place, life, growth and history.

- Wooden instruments (particularly those that are luthier-built) are the result of sustained and hard-won human effort; of skilled craftsmanship, developed through years of practice and study and which is held in admiration and in high esteem.

These convictions combine to have an effect, at least in the minds of many ‘guitar club’ enthusiasts, of enriching the act of music making: in seeing wooden instruments within a spiritual as much as a physical domain. Proponents are therefore if not vehemently opposed to changes in material use for guitars, certainly very reluctant and view change with some disdain (Armstrong, 2002). In fairness though, this perspective is probably far too elitist to fit

most guitar buyers, but the principles are clear enough and illuminate the difficulties to be faced in the transition from wood to plastic.

Sensorial Information From Plastic

Whilst the affection towards wooden musical instruments is well established, the same cannot be said for synthetic materials. Within the minds of the public and some sections of the acoustic guitar community there exists, albeit lessening now that new technologies are slowly coming to the fore and deserving of attention, a sense of denial that plastics can recreate anything near the satisfaction and emotional attachment that is apparent with a wooden instrument. Moreover, the use of plastics is purported to somehow debase music making, with the term 'plastic' in rock'n'roll circles referring to "faking it" (Blincoe, 2002). As will be seen, this prejudice is in part well founded, and is shaped by (i) the aforementioned positive sentiments towards wood, (ii) reluctance to change the satisfactory status quo, and (iii) negative connotations raised by the concept of combining 'musical instruments' with 'plastics'.

Let us first take a look at negative connotations surrounding plastic as a material, regardless of product. Being synthetic, plastic has stigmas of artificiality, anonymity, conformity, and lifelessness. Plastics are perceived to carry coldness of production; of monotonous, regimented and characterless production lines. When converted to products, plastics can still carry a popularist 'cheap and nasty' image: 'cheap' because plastic products are sometimes suspiciously low in cost, and 'nasty' because the experience of owning and using plastic products sometimes instils much displeasure. Ultimately, both 'cheap' and 'nasty' point to a low quality product and a poor quality experience.

So who is to blame? It is not fair to pin the negativity back to the pioneers of plastic products in the early and mid twentieth century. They inevitably had their failures as they found their feet in what was a new and emerging field. We should probably look to more recent history and the explosion of plastics specifically as a 'replacement' for established, traditional and often more expensive materials. The driver for this replacement in many cases has not been to advance product utility or aesthetics, but simply a case of reducing costs and squeezing markets: the mass manufacture of plastic products makes good business sense and the lure of lower prices is irresistible to consumers. The end product often suffers. Around my own

household, it is easy to identify inferior plastic products: bent kitchen utensils (originally rigid stainless steel), shattered fibreglass tent poles (originally rigid aluminium tubing), cracked food bowls (originally glass), and faded car trims (originally chrome-plated steel). This trail of unsatisfactory 'replacement' plastic products compounds the reluctance to accept that plastics can satisfactorily replace wood in musical instruments.

We should however recover some perspective, and acknowledge that plastics have radically changed the material world and, when used sensitively, have provided admirable advances in product utility and aesthetics, even as a 'replacement' material. For example, squash racquets (now carbon-titanium fibre, see Figure 1), racing rowing boats (now carbon fibre), surfboards (from redwood, to pine, to balsa-fibreglass, to encased foam), aeroplanes (now many different composites, metals and plastics), football goalposts (now uPVC or aluminium) and beer barrels (now aluminium). Wooden varieties of each of these products are now historical items, superseded on utilitarian and aesthetic grounds by non-wood replacements.

Figure 1, Transition from wood to synthetic materials in squash racquets: Slazenger Whippet (1985) and Head Ti.15X (2003)

The most prominent exponent of plastics in the field of musical instruments has been Mario Maccaferri. On the back of great success with plastic ukuleles, in 1953 Maccaferri introduced his G30 and G40 plastic acoustic guitars, mass-manufactured from Dow Styron (Figure 2).

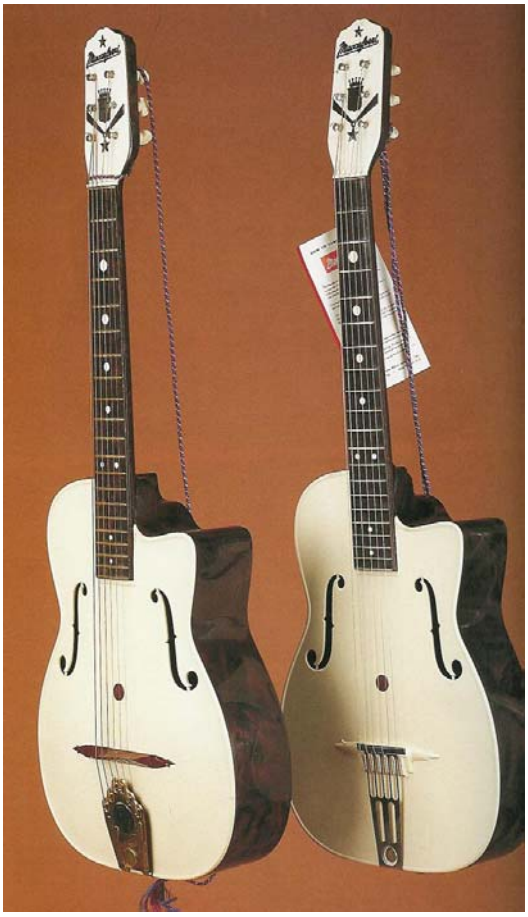

Figure 2, Maccaferri polymer acoustic guitars

These instruments, and subsequent revisions, had poor tone and as consequence failed in the marketplace. In the following decade, spurred on by the growth of television advertising and celebrity endorsements, various miniature injection-moulded 'toy' acoustic guitars became prolific (Figure 3). These did nothing to help the cause of quality plastic musical instruments. Soon after, the introduction by Ovation of 'bowl back' acoustic guitars made with Lyrachord further divided opinion on the merits of integrating plastic components into acoustic guitars and on the tonal qualities possible with such materials.

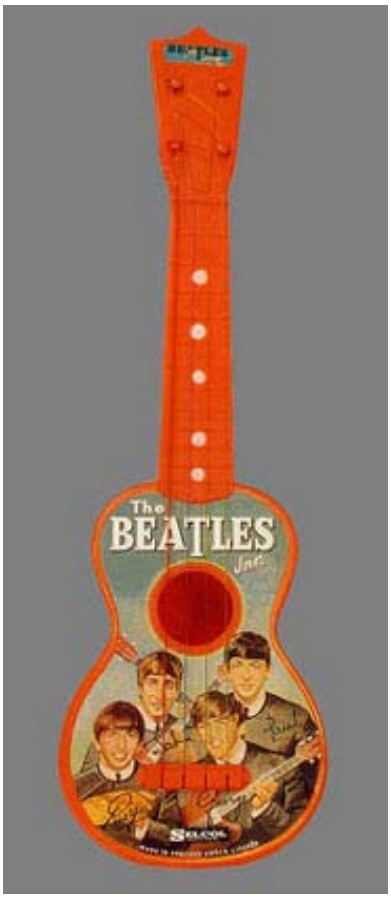

Figure 3, 'Beatles' toy polymer acoustic guitar

In the most recent decades, the use of carbon fibre amongst specialist acoustic guitar makers has increased. Opinion is again divided on the tonal success that can be achieved, but being relatively expensive as a material, coming from aerospace roots and with a striking weave appearance, carbon fibre has an undoubted allure that contributes positively to the field of synthetic musical instruments. The most prominent use of plastics for musical instruments is with woodwind, where for example plastic recorders and clarinets are now well established as quality instruments, indeed preferable to wood for learner instruments.

Design Approach

The design approach for the *Cool Acoustics* polymer guitar, having established that the instrument was indeed technically plausible (through rough lash-ups), was to focus on creating high quality, desirable prototypes. These instruments were required to satisfy the three most important qualities from musicians' perspectives when evaluating a new guitar: appearance (instruments are firstly glanced at), feel and playability (instruments are then

handled and played) and tone (instruments reveal the nuances of their tone after extended playing). Failure to attend to any one of these areas of affective product design would have jeopardised our ability to create a credible instrument.

As part of a practice-based PhD (Pedgley, 1999), the design activity that led to the guitar prototypes was systematically documented in a daily 'diary of designing'. The diary has been helpful in recalling the rationale for designing for tone, appearance, feel and playability. The following pages describe aspects of the development of what we now refer to as model FFS2002-1 instruments (exhibited at the Frankfurt Musikmesse 2002).

Designing for Tone

Our collaboration with English luthier Rob Armstrong helped us to focus our ideas, and in particular steered our design rationale for achieving good quality tone. Designing for tonal qualities, which was essentially achieved by narrowing down the choice of underlying materials to a combination of foamed and solid resin polymers, and by paying particular attention to the 'one-ness' of instrument construction, goes beyond the scope of this paper. Further information is available in previous publications (LUEL, 2000; Norman *et al.*, 2000), suffice to say that the quality of tone produced with Cool Acoustics™ technology is accepted by a large majority to equal that of fine tonewoods.

Designing for Appearance

Sounding Box Form and Finish

As an archetypal product (Thistlewood, 1990), the form of the sounding box (or main body) of an acoustic guitar is generally realised as a variation on a fairly restricted theme. To explore the boundaries of the legitimacy of 'extreme' sounding box forms, an analytical exercise was undertaken (Figure 4). The exercise made explicit the essential attributes of instrument body profiles that differentiate an acoustic guitar from other stringed musical instruments, and determined the boundary at which an instrument body profile ceases to describe an acoustic guitar. The following attributes were established.

- Two distinguishable bouts (upper and lower) must be present.

- A waist (overlap) must exist between the upper and lower bouts.
- The upper bout must be of smaller width than the lower bout.
- The lower bout must have a conservative base curve.

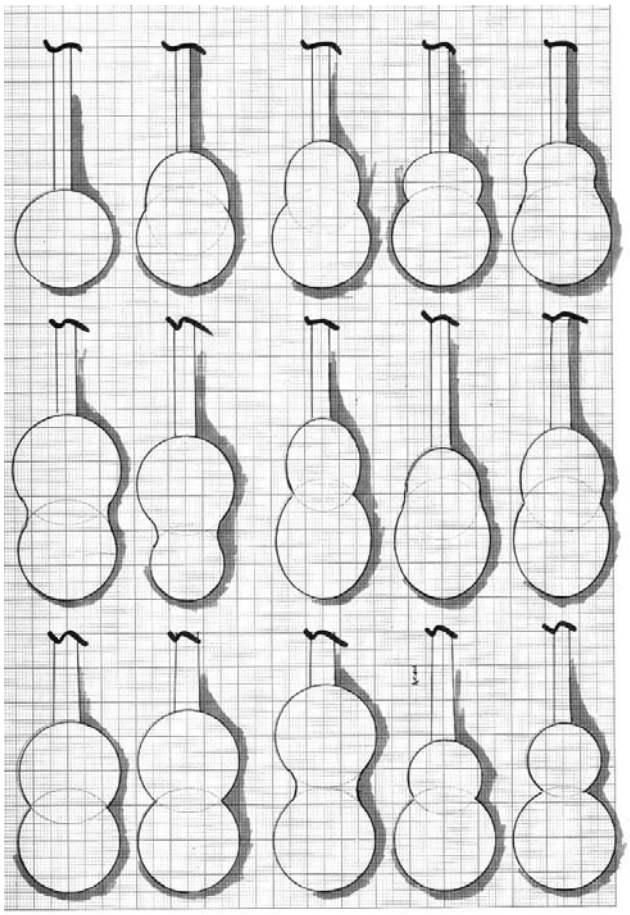

Figure 4, Establishing the essence of an acoustic guitar body profile

A relatively small-sized sounding box was chosen (380mm lower bout width, 90mm depth) to give a personality character that was discrete and intriguing compared to a standard Dreadnought style guitar, and which also satisfied acoustic requirements. Emphasis was placed on creating a highly curvaceous form that was obviously moulded and distinct from a fabricated component. It was important to distance the instrument from the raw, aggressive lines typically used for polymer electric guitars. To add distinctiveness to the instrument body profile, both bout shapes were based on ellipses with forward-sloping major axes (LUEL, 1998a), and the main body, neck and headstock were consolidated into a single component.

The various plastics used to prototype the main body were visually uninspiring in their untreated state. They were thus treated as a blank canvas for highly glossed, vibrantly coloured painted surfaces – the antithesis of finely sanded and lacquered wood – to underline product differentiation and create an emotional stir (Figure 5).

Figure 5, Vibrant paint finishes to the contoured one-piece main body

Bridge Form and Finish

The intention with the bridge was to produce a striking new form but to uphold the principle of 'truth to materials'. Visually stunning recycled acrylics requiring no secondary finishing were used (Figure 6). The bridge form was deliberately developed to have a 'machined' aesthetic (LUEL, 1998b), in purposeful contrast to the curvaceous main body and creating a focus for the eye amongst the relative plainness of the soundboard.

Soundboard Form and Finish

The soundboard material was selected for acoustic properties and its shape was governed by the instrument body profile. The truth to materials principle was again important, with no

secondary finishing of the soundboard being proposed. The selected material was visually exciting and did not deserve an attempt to mask its properties. In a stroke of good fortune, the satin appearance of the material visually complemented the high gloss of the main body.

Figure 6, Truth to materials: machined recycled acrylic

Designing for Feel and Playability

Basic Unchanging Attributes

Using a list developed by Chrysalis Guitars (1998), the basic unchanging attributes that make an acoustic guitar playable were established, with anything unmentioned suitable for experimentation.

- A rigid neck.
- An acoustically compliant sound-making surface.
- A rigid support structure attached to the neck that supports the sound-making surface around its periphery.
- Strings under tension held rigidly at one end of the neck, and held at the other so that the strings are mechanically coupled to the compliant portion of the sound-making surface.

- The ability to allow listeners to perceive sound vibrations in the range of 50Hz to 6000Hz.
- An overall structural rigidity sufficient to keep the strings 'in tune' during normal handling and playing to several cents.

The Cool Acoustics instruments embody each of these attributes, but a decision was taken not to produce an overtly provocative or unusual configuration (such as the collapsible instrument developed by Chrysalis). Caution was exercised because it was felt that changing just *materials* was in itself a sufficiently radical step. To change product configuration as well as materials would have been a step too far, rendering the resulting instruments obscure novelty items rather than credible alternatives to mainstream acoustic guitars.

Anthropometry and Interaction

The results of an ergonomic re-design of an electric guitar (Marmaras and Zarboutis, 1997) were studied, which usefully prescribed preferable dimensions and layouts according to ergonomic principles. In general, no deviation from 'standard' dimensions and features was made, thus avoiding peculiar playing traits. Weight was important, and it was thought better to edge on the heavier side to counteract any claims of being flimsy, un-robust or cheap. The neck and fretboard geometry – essential for good playability – were direct copies of hand crafted and contoured Rob Armstrong components. Pigmented rather than painted material was used for the fretboard in order to avoid wear marks over time. The fretboard surface finish had a similar feel to wood.

Designing for Other Factors

Respect

Cool Acoustics has not come cold to the music industry: the craft sensitivities of a professional luthier have gone into the making of the instruments. The large moulded Armstrong 'A' emblem on the rear of the body is proudly displayed, and selected attributes of Rob Armstrong wooden instruments have been reproduced (e.g. the headstock form, the approach to creating a good set-up). The link to traditional guitar-making is seen as vitally important for gaining respect and providing quality reassurance.

Longevity

Cool Acoustics has continually disassociated itself from the notion that polymer acoustic guitars can be short-lived 'throw-away' products. Indeed, as a replacement for prized and diminishing tonewoods, Cool Acoustics™ technology should be equally cherished and built to last.

Terminology and Brand

The use of the terms 'polymer' and 'Cool Acoustics™ technology' in place of 'plastic' helps from a semantic perspective. Images of bubbles have been used in promotional material, communicating not only the physical structure of foamed polymers but also the venture metaphors of lightness, effervescence, accessibility and freedom.

Olfactory Experience

Although not intentional, the plastic/adhesive combination in Cool Acoustics instruments has a characteristic smell, closer to the smell of a new car than a new wooden instrument.

Product Evaluation

Four prototype instruments were debuted at the 2002 Frankfurt Musikmesse, where they were studied and road-tested by the music industry and public. An informal log of responses was made during the Musikmesse. Overall, visitors were impressed with the instruments and very supportive of Cool Acoustics' aims and achievements. Talks regarding commercialisation have since followed with major manufacturers: an indication that we succeeded in making polymer acoustic guitars credible. In addition, our instruments have received endorsement from world-respected acoustic guitarist Gordon Giltrap, adding further weight to the quality of our venture. Product evaluations were also made by thousands of school-age children during the 2002 Tomorrow's World roadshow exhibition in the UK. The striking appearance of the instruments captured many of the children's imaginations.

Conclusions

The approach to 'designing in credibility' and 'designing out prejudice' for polymer acoustic guitars centred on careful material selection, finishing and form creation and a heightened regard for affective product design. It also relied on a watchful analysis of the relative merits

of wood and plastic in product design and the sensigneous properties of each material. There is still much to do in moving from a state of *credibility* to a state of *heartfelt affection* for polymer acoustic guitars, but a secure course has been taken and a portfolio of new instruments and a market presence will help in achieving the goal. The work to date, grounded in the field of design and emotion summarised by Desmet (2004), adds much weight to dispelling the continued prejudice against the use of plastics for musical instruments. In addition, parallels can be drawn for designers working in other (unrelated) product areas, whose task is to elicit favourable emotional responses from plastic versions of archetypically traditional, non-plastic products.

As products eventually become available for sale, effective communication of concept, technical specification and desirability will be key to attracting purchasers and to swaying purchase decisions in favour of instruments made with Cool Acoustics™ technology. But equally the sell should not be over-emphasised: the instruments must stand alone on their own merits without the need for description or explanation. It is hoped that such a balance will be struck in the first publicly-available instruments made with Cool Acoustics™ technology, for which we are compiling a register of potential purchasers via our website (Cool Acoustics, 2004).

Acknowledgements

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REFERENCES

Armstrong, R. 2002. Personal communication.

Bacon, T. 1991. *The Ultimate Guitar Book*. London: Dorling Kindersley.

Banks, R. ed. 2001. *The Illustrated Dictionary of Guitars*. London: Salamander.

Blincoe, R. 2002. "Plastic Rocks!" The British Council Culture Lab. Available from URL: <http://www.culturelab.co.uk/site/templates/issue1/archive_item_culturelab.asp?ID=115> [Accessed 01.01.2004]

Chapman, R. 1993. *The Complete Guitarist*. London: Dorling Kindersley.

Chrysalis Guitars. 1998. Available from URL: <http://www.chrysalisguitars.com> [Accessed 01.01.2004]

Cool Acoustics. 2004. Available from URL: <http://www.coolacoustics.com> [Accessed 01.01.2004]

Denyer, R. 1982. *The Guitar Handbook*. London: Pan Books.

Desmet, P. 2004. "From Disgust to Desire: How Products Elicit Emotions." In *Design and Emotion: The Experience of Everyday Things*, edited by McDonagh, D., Hekkert, P., Erp (van), J., and Gyi, D. 8-12. London: Taylor and Francis.

Gruhn, G. and Carter, W. 1993. *Acoustic Guitars and Other Fretted Instruments: A Photographic History*. San Francisco: Miller Freeman Books.

LUEL. 1998a. *Registered Design Right 2074916* (Guitar Body).

LUEL. 1998b. *Registered Design Right 2074917* (Guitar Bridge).

LUEL. 2000. *World Patent Application PCT/GB00/03073 published as WO0115135*.

Marmaras, N. and Zarboutis, N. 1997. "Ergonomic Redesign of the Electric Guitar." Applied Ergonomics, 28(1): 59-67.

Norman, E., Heath, R., and Pedgley, O. 2000. The Framing of a Practice-Based Ph.D. in Design. Core 77 website. Available from URL: <http://www.core77.com/research/thesisresearch.html> [Accessed 01.01.2004]

Owen, C. 2002. Plastic Bassoons. Available from URL: <http://www.geocities.com/Vienna/Strasse/4852/bsnchoose.html> [Accessed 01.01.2004]

Pedgley, O. 1999. *Industrial Designers' Attention to Materials and Manufacturing Processes: Analyses at Macroscopic and Microscopic Levels*. PhD thesis, Loughborough University.

Pearce, F. 1993. “While My Guitar Destroys the Rainforests.” New Scientist, 18 December. 140(1904):8.

Roberts, J. 2001. The Future of the Guitar and Bass. Available from URL: <http://www.guitar-bass.com/main/features/future/future.htm> [Accessed 29.08.2001]

Thistlewood, D. 1990. “The essential disciplines of design education.” In *Issues in Design Education*, edited by Thistlewood, D. Harlow: Longman, 14-29.

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